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Propagation of Certain Ornamental and Economic Plants

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PROPAGATION OF CERTAIN ORNAMENTAL AND ECONOMIC PLANTS

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

George Charles Klehm, Jr.

ENTITLED Propagation of Certain Ornamental and Economic Plants

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Floriculture

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Instructor in Charge

APPROVED:

HEAD OF DEPARTMENT OF Horticulture.

P R E F A C E

At the beginning of my college career, I took especial pains to find a vocation which would give me a good living wage and happiness as well. (Fortunately, I received some very good advice in regard to the various well beaten paths of engineering and science.) Being brought up in a nursery and under glass for a great part of my time, I very soon realized after my absence from home, a great love for nature in all of its forms and colors. Enabled by my younger experience to see that the field was large and that an intimate knowledge of the plants was necessary, I decided to enter a university. Having decided that I wished to become the greatest propagator and grower of hardy plants, I looked all over the country for a university which would satisfy my requirements. After a diligent search I found that the University of Illinois furnished about the best course in regard to such plant life, yet I did not find any university which would furnish exactly what I wanted, though I must say a word of Thanks and pay tribute to the University of Illinois for what it has done for me.

Champaign, Illinois,
May 1, 1915.

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INTRODUCTION.

Before the great continental war broke out in August, 1914, millions of dollars worth of young plants had been annually imported into this country from Holland, Belgium and France. Two of these countries, Belgium and France, were soon in the throes of that great struggle and the importation of many plants from these countries was temporarily hindered or stopped entirely. Holland, though not engaged in that tremendous struggle, was compelled to mobilise its armies to maintain its peace. Its ports were hampered by blockades, and here also the exportation of plants was hindered. These causes produced some anxiety to those Americans who depended upon the importation of stock from Europe.

On top of this came a decree from the U. S. Department of Agriculture, forbidding the importation of Pinus Strobus after June 1, 1915.

That propagation of American stock should be extensively carried on is the opinion of many people of this country. If the plants are well propagated so that they are strong and healthy, the demand for young plants "Made in America" is sure to increase and multiply. Three years ago our nursery - (Klehm's Nursery - Arlington Heights) propagated about 75,000 young plants of our general lining out stock. The resultant demand for the goods at that time far exceeded our supply and we were forced to cut down the size of our

species. As a consequence, we have now over a million and a half started and growing. Further encouragement was also given by the large number of complimentary letters which we received, among them being one from Thos. Meehan & Sons. Our customers far and wide were more than satisfied; they expressed the fact that plants were strong, were less troublesome, and grew a greater percentage than would have ordinarily been done from European grown stock. Although our labor costs more than twice as much as it does in Europe, we still believe that we can compete.

In general the soil in America is not as fine a loam as that in the European countries mentioned. For instance, Boskoop, Holland, which is the home of over seven hundred nurseries varying from a few square feet to a number of acres in size, has an ideal peat soil, rich in humus and always evenly moist but never wet. The sea climate with its moist atmosphere facilitates propagation and the absence of sunlight due to fogs, produces a softer growth than is generally found on plants grown in America. The winters hardly ever become colder than fifteen degrees above zero Fahrenheit, and the soil may be worked at nearly all parts of the year. Belgium has a similar soil. Both of these countries are thoroughly traversed by many canals, and as an agent from Holland told me, "It works like a machine. When it becomes too wet, we pump the water out into the canal, and when it becomes too dry, we let a little water run in from the canal." Yet they have their fine backs. Land is figured on the basis of a roe, which consists of a patch twelve feet long and twelve feet wide. The cost of this small lot is from six to eight dollars, and the cost of an acre estimated on the same basis, varies from $1815.00 to $2120.00.

Plants which are secured from these countries have a soft woody growth which might often be called pithy. Such is the case with their hydrangeas, weigelias, and roses. When these plants are planted in America, it often takes three years to produce wood which becomes hardened enough to withstand the rigors of our climate. Continual propagation of these plants forms softer wood growth, causing plants to freeze out or freeze back to such an extent that some plants which should have a place in some of our northern plantings are not to be found there.

Formerly the duty of 35% of the cost price was paid on imported nursery stock, but at the present time the import duty is 15%. This necessarily injures the American producer but since he cannot regulate the tariff to suit himself, it exemplifies the fact that he needs quicker and more certain methods of propagation for competition with European labor.

The American nurserymen should have methods which would give a greater percentage of young plants from a given amount of stock and should have cheaper methods than those in use at present in order that he can overcome the advantages enjoyed by European producers. The reduction of the tariff, the knowledge that better stock is sure to be obtained, and the opinion that greater and better results may be obtained, with other unavoidable conditions have forced American nurserymen to look about for quicker, easier, and more certain methods of propagation suitable for the various plants and the varying climatic conditions.

Five years ago I began experimenting at Flehm's Nurseries with a view of securing cheaper and better methods of propagation than those commonly used by American nurserymen. During this last

year - fall of 1914 combined with the spring of 1915 - I have conducted various experiments at the nursery and have made a number of experiments on seeds here at the University. I have also corresponded with a number of nursery firms both in Europe and America. Valuable information has been secured from the following persons:

Mr. W. J. Chapman, Arlington Heights, Illinois, U.S.A.

My father, George C. Klehm, Sr., Arlington Heights, Illinois.

Henry Lake Pars Co., Black River Falls, Misc., U.S.A.

U.S. Dept. of Agriculture, Washington, D. C.

The E. Will Nursery Co., Inc., Dundee, Illinois, U.S.A.

Otto Katzenstein & Co., Atlanta, Ga., U.S.A.

Thos. Meehan & Sons, Dresher, Pa., U. S. A.

C. L. Williams, Seed Collector, Exeter N. H., U.S.A.

Barbier & Cie., Orleans, France.

Felix & Dykmans, Boskoop, Holland.

Due to the presence of this great war, members of Belgian, German, and French nurserymen to whom I wrote were unable to reply.

The plants mentioned in this thesis are those which are difficult and hard to propagate or they are those in which some special treatment provides a beneficial and desirable result.*

*I assume that the reader is familiar with the methods of propagation, but if not familiar, I recommend that he refer to "The Nursery Book" by L. H. Bailey, for further information.

— II —

F R U I T S.

The propagation of fruits is generally well known, but in an endeavor to show some methods for the improvement of these plants, I have introduced a few facts which are undoubtedly of interest to fruit growers. The use of particular stocks and methods in the cause of varying conditions and the means of obtaining some very beneficial results.

Apples.

These fruit trees are easy to propagate and are made by budding or grafting. The tongue graft is the graft usually employed. Experiments on the value of grafting waxes have been conducted at home. The hard wax formula of seven parts resin, two parts bees-wax, and one part tallow was once employed, and was applied by means of a cloth rag on the end of a stick. Later a formula was found in which the amount of bees-wax used was cut in half and an equal part of red ochre was substituted for the bees-wax. This formula was found to be very good when a very permanent wax was required. Later we found that apple grafts if made out of doors at the proper time without wax, grew from two and one quarter to three times as much the same pattern as those with wax. But on further experimentation it was found that the method did not apply favorably in all cases, so that now it is abandoned in favor of the waxed paper formula, which has given us satisfactory results, even though it causes a constriction of growth.

Some apples, an example being the Northern Spy, should be grafted with a short root and long scion in order that grafts may be planted deep enough so that the scion will make its own root. The benefit from this process is greater longevity in the tree, on

account of the resistance of Northern Spy roots to woolly aphis. Grimes Golden is often top-worked on Spy on this account and also on account of its extreme hardiness.

Pears.

This fruit is grafted or budded in a way similar to the apple, the bouque graft being the essential manner in which it is grafted. The greatest difficulty in growing pears is the trouble with the ravages caused by fire blight. Trees propagated on pear stock invariably suffer from this far-fetching disease. Only those half-immune varieties such as Bieffer and Winter Nellis are partially exempt from this disease. The greatest trouble with blight is at the time they are about to bear some fruit, the great trouble arising from the infection of the blossom by insects. We have found that pears grafted on **quince** are remarkably unaffected by blight. Varieties most susceptible such as Bartlett, Clapp's Favorite, Louis Bonne of Jersey, and Vicar of Wakefield, have been grown consistently for at least ten years without a trace of blight, at my home, although the same varieties grafted on pear stock have shown a great loss. By grafting on quince, pears are dwarfed somewhat, but I would not be surprised to see pears grown consistently for commercial purposes on this stock.

Cherries.

Usually propagated in Europe on Mahaleb or Mazzard stock. French propagators use the Mahaleb on account of the fact that it dwarfs the cherry tree somewhat and also because it makes a vigorous growth. Budding and grafting are usually the methods employed. We use another stock known as the Morello which has proved far more effective as a stock in Cook Co. George Klehm, Sr. says: "In our

experience of nurserymen and orchardists of the last fifty years at Arlington Heights, we find that one tree grafted on Morello stock in this locality will bear as much as five, grafted on Mahaleb or Mazzard."

Mr. J. L. Budd, late professor in the Iowa State College, and Mr. N. E. Hansen, professor in the South Dakota Agricultural College, write in the American Horticultural Manual, about western experience of the cherries grafted on Morello as follows: "In Dupage County, Illinois, over forty years ago, James Wakeman top-worked Early Richmond on stocks now known as American Morello. The history of this cherry is not known. It is worthless for fruit where better varieties can be grown, but it has remarkable vigor and hardiness and has been scattered by means of sprouts over the whole Northwest. The large commercial orchards, top-worked on this stock, have borne heavily and regularly, and have outlived two or three generations of Early Richmond nursery-grown trees on Mahaleb roots."

Plums.

Plums are grafted by tongue or side graft out of doors. Many nurserymen propagate on stock known as the Mirobolan stock which is not quite hardy to all northern conditions. A few years ago the plums in the plot back of the Horticultural Building were very seriously hurt by a hard winter, very few trees remaining standing due to the fact that the roots were not hardy. As a remedy for this condition, we have been grafting all of our plums on Prunus Americana seedlings, which we have grown ourselves. Many people can vouch for the hardiness of our stock and many examples can be found around Chicago where we carry on an extensive retail trade.

Peaches.

Peaches are generally budded on seedling peach stocks, but at the present time we are going to make an endeavor to graft them on an apricot stock which we have discovered in a cold region. We know that this apricot is a good root for peaches, as at present half of the apricots in the orchard are top-worked to peaches, which have withstood the tests that have been put to them for many years.

Grapes.

Grapes have generally been made by means of long and short cuttings in this country for many years. After the introduction of hylloxera in Europe it was found that the European grapes, which were not resistant to that disease, had to be propagated on some American root stock, which would not be affected by this disease. Grafting was resorted to and a number of different methods were tried. California later on took up the subject of grape grafting for wine purposes in an effort to grow those grapes which would produce those wines and champagnes of higher quality and excellence. They were successful and now grow nearly all of the varieties of grapes which are grown in Europe. Through the kindness of Mr. W. P. Chapman of Arlington Heights, we have been interested in the growing of these varying varieties in the North Central States. Vitus Riparia and V. Ruprestris stocks have been used on account of their hardiness. The method in use is the splice graft. Grafts are put away to callus in moist situations with a temperature of about eighty degrees F. At the present time we have a few plants for stock purposes on hand known as V. Riparia X V. Ruprestris No. 3309, which we have received from Mr. Chapman. This is a cross from France which is said to be exceedingly vigorous and hardy, having withstood temperatures in

regions as low as forty degrees below zero F. The resultant effect of grafting on this stock on a number of varieties is as follows:-

a. Ripens Concord fifteen days earlier in this vicinity; thus allowing them to compete with New York-Chautauqua District grown Concords in sugar content, ripeness, and fine flavor.

b. Gives the Delaware a root which will not winter kill.

c. Will allow the use of the Iona in all kinds of soil; gravel is the only soil in which it will grow at the present time.

d. Will enable Campbell's Early to grow here because the root has a tendency of making the wood ripen early in the season; thus protecting the plant from the winter freezes.

V. Riparia Gloria at present is a good stock for our Illinois corn soils. It will make Concords ripen ten days earlier. Catawba is also a fairly good stock because it adds enough sugar to our western grapes, making them equal to the Lake Erie grapes, which now have a superiority of 15% greater sugar content. Both of these stocks are excellent, yet we believe that V. Riparia and V. Rupestris No. 3309 are better than either of these stocks.

Currants.

These bush fruits are very easily propagated from cuttings. The finer varieties of currants, namely those of the larger berried type; Fay's Prolific, Cherry, Perfection, Red Cross, etc., are very slow in making sufficient wood for the picking of cuttings. The average plant of Perfection, two years old, has a top not more than six to eight inches in length, so that this variety will necessarily continue to be expensive, although it was introduced a number of years ago. To overcome this difficulty, we resorted to the following experiment at home:

In the fall about the tenth of September, 1916, after the currant were ripe, we cut off a number of plants of the strong growing variety Victoria, below the surface of the ground. On the root left in the soil we grafted a number of short bud cions of Perfection secured by means of bide graft. We filled the hole up with soil and allowed them to remain throughout the winter. In spring I uncovered the grafts personally and found them well callused. By fall the resultant one year old Perfection currant plants were two feet high, equivalent to the same variety four years old from cuttings. During the past year they bore fruit in abundance and last fall grafting was again resorted to, a large quantity having been made. At the present writing, May 10, they have shoots four to six inches in length.

Gooseberries.

These bush fruits are not so very easily propagated on account of their thorns and also because they do not make well from cuttings. It seems that there are only a few nurserymen who handle plants in large amounts, the other nurserymen usually buying whatever stock might be needed. The best method which I have found adaptable is the method known as mound layering. The stock plants are planted in what we usually term a double furrow. The first year they are grown in this situation with an effort to make the plant sprout as close to the ground as possible, and the growth is about as vigorous as the best fertilizer will permit. The second year is when the layering is done. Before the first of June, (generally between May 1 and June 1) the ground about the plant is hilled up on to the plant as high as possible by the use of disc cultivators and shovel plows. In the fall or spring while the plants are dormant, the ground is

removed. The plants are taken up and the rooted limbs are cut off and planted immediately for next year's crop".

—III—

DECIDUOUS SHRUBS AND ORNAMENTAL TREES

For a number of years we have been troubled with the propagation of our finer varieties of shade trees. Large numbers of Magnolia, Betula, Fagus, and Acers, have been imported annually, due to the finer qualities shown by European stock and the difficulty experienced in the propagation. The finer quality is due to the method of handling of the stock. Even Crimson Acer pleniflorum is easily propagated from seed, it will serve as an excellent example. Grown as it usually is in America, anyone would find great difficulty in selecting a straight, clean tree because of its side branching habit. It is usually unsightly because of its knots and other marks of crudity. European stock is remarkably free of this trouble and every tree is usually as straight as a pencil. Why. The European nurseries have found out just what a number of American nurserymen ought to know, and this is what they do: When the small maple is two years old and fairly strong, it is cut back down to the ground. Care is taken that only one bud develops at the base of the plant. The resultant growth from this pruned plant is a straight one year shoot which is longer than the growth which was cut off, giving the young tree just what is wanted, a tree with a trunk perfectly straight and with hardly a blemish.

Acer, commonly grown from seed, some varieties grown as follows:

A. Virginicum Vieri lucinatum; grown in France from layers. We have propagated these maples by budding them on Acer Saccharum, but our resultant success has been only nominal, because only about 33-35% would grow. As a rule, kinds belonging to different groups

cannot be grafted on each other. At present we have . for experiments of grafting by the veneer method in greenhouses on stocks grown in pots. Japanese varieties are usually worked on A. palmatum.

A. plat oides purpureum Goeschleri.

A. platanoides purpureum Reitenbachi.

These trees are usually budded in Europe. On account of the harder wood growth in this country, many nurserymen graft them. Various methods are in use, the veneer graft being most desirable. We have used the side graft at home out of doors because it usually saves about one year in the growth of the plant.

Betula.

The rare varieties are usually grafted on B. lenta, B. nigra, B. papyrifera, B. vigra, or B. verrucosa. Cleft or tongue grafting on potted green house stock is generally recommended. Veneer budding is sometimes practiced but seldom very successfully. My experience with these plants has been the result of year's of experimentation. Our usual trouble is due to the entrance of fungi at the graft. Closing the wounded part entirely with wax so as to exclude fungi does not give very good results, due to the fact that the wound is not able to heal properly. The only seeming good method which we have found was, that the plants should be put in a clean medium, wood preferred. The water should be very sparingly applied, but the soil should be fairly moist. March seems to be about the best time to carry on this work. European propagators seem to have about the same trouble, as their one or two years old grafted stock costs usually from seven to ten cents wholesale.

Fagus.

The rare varieties of these plants are usually obtained

from Europe on account of our trouble to propagate them. Mr. Felix of Zelis and Lyboin, Boskoop, Holland, tells about the propagation as follows: 'Carus sylvatica purpurea, grafted on Carus sylvatica by cleft or fl, either high or at the crown of the roots. This is done in March and April in the fields. They are also propagated by inarching, which is also done in the fields in March and April. Round a tree of Carus sylvatica purpurea are planted several stems of Fagus sylvatica. As soon as they are well established, the inarching is applied. It takes about eight weeks before they are united and may be separated. (By simply cutting the branch) It is better not to separate them until fall.'

This method is far more successful than cleft grafting and I find that after a number of experiments at home, inarching is too expensive if done in America, because of a number of failures on account of our drying winds. At present I know of no good American method which can compete with European grown stock.

Gleditschia.

This tree is undoubtedly the best tree for use in cities. It will withstand more neglect, more sand, and more smoke while still being graceful than any other tree grown at the present time. Chicago's small parks give silent evidence of this fact. G.Triacanthos is not very desirable because it has thorns varying from three inches to a foot in length. G.Triacanthos inermis is more essential because of its absence of thorns. European propagators make by inarching. We have experimented on grafting and we find that the wood is very hard, and that cions do not take when the plants are propagated out of doors. Up to this date I have not found any method to take the place of inarching, though I have made experiments of many kinds which have not

given the approximate percentages which are necessary to call them successful.

Magnolia.

The common varieties, M. kobus, M. macrophylla, and M. tripetala, are grown from seed. The finer varieties, M. Soulangeana, M. Lennei, M. Thompsoniana, M. purpurea, and M. Soulangeana, are made by means of layers. M. Halleana stellata and the better plants of Magnolia conspicua are grafted by means of inarching. Grafts, both cleft and veneer, which I have made during 1915 have given no promise of success, as they have not callused. The methods shown above are those which are employed in Europe, and at the present time they seem to be the only feasible methods to use, further experimentation being necessary.

Populus.

A few varieties of these trees do not make very well from cuttings, Populus Alba Bolleana being one of them. When in search of a tree of quick growth of this variety, we resorted to grafting by means of cleft graft on P. Caroliniana, but while experimenting on grapes, we discovered that P. Alba Bolleana would grow an immense callus on the cutting if given plenty of moisture and heat amounting to about eighty degrees F.

Prunus.

European propagators make all of the finer varieties of this species on Prunus Mirobolana, by means of either budding or grafting, cleft graft or side graft being generally used. Whether we deal with the ornamental variety or those varieties valuable for their fruit, we still maintain that more suitable and hardy plants can be obtained by grafting on Prunus Americana. Our plants of the varieties P. triloba flora plena, P. Pissardii, P. Sinensis flore albo pleno

as well as P. sinensis flore rubro plena are always fulfilling a great demand for hardy stock; and with the best endeavor to give the American people the best that they can get for their money, we shall continue to offer them Prunus of all kinds grafted on native stock.

— IV —

I V E R G R E E N S.

Up to the present time Europe has been exercising the greatest interest in the growing of the various conifers. Barbier & Co. of Orleans, France, list ninety-three varieties of Abies, fifty-two varieties of Cupressus, forty-six varieties of Juniperus, thirty-two varieties of Pinus, twenty-eight varieties of Retinospora, thirty-five varieties of Taxus and fifty-three varieties of Thuja. A large number of these varieties must be made either by grafting or from cuttings.

Abies.

All of the Abies which cannot be grown from seed are made by grafting on (usually) Picea excelsa. The stocks are two to three years old, and must be of pencil thickness. The method in use as described by Felix and Dybbuis, and Barbier & Sons, is the veneer grafting method. They are made in August and the grafting is performed in pots and the grafts are placed under double glass so that a temperature of at least seventy degrees F. is maintained. It takes about six weeks before they unite, after which the tops are cut off and the plants are taken out of the pots and placed in cold frames to harden off. Dropping syringe to not cover them with sphagnum as used in Bailey's book, but except this, they are handled about as described therein.

In our experience we use a so-called side graft and make them directly out of doors without the use of any glass at all. We make them in spring, mound the graft with earth and allow them to remain in that position until the following spring. Then we cut off the tops and allow the scion to grow. Our average success by this

method has been about 65% of all grafts attempted. This method saves time and avoids all of the extra handling which is required of those plants in pots.

Cupressus.

These are made in March to May by veneer graft upon Cupressus Lawsoniana seedlings, two to three years old. We find that we can make them from cuttings with a little bottom heat and plenty of shade. Time of making is April and May. Our method of side graft is also used here.

Juniperus.

These are made by veneer grafts in a similar manner to the way fine varieties of Abies are handled. The stock used is Juniperus Virginiana. We find that the simplest way to make them is by means of cuttings, taken in spring with a little bottom heat and shade.

Pinus.

Most of these can be propagated by means of seeds, using charcoal, sulphur, or a spray of sulphuric acid, 1-1000, to avoid fungus attacks. A few have to be grafted, the stocks in general use being the seedlings relative to the variety which is to be grafted. Example: When P. Strobus umbraculifera is wanted, the stock is P. Strobus; when P. sylvestris pyramidalis is wanted, Pinus sylvistris is usually used as the stock. All of the rules belonging to the veneer grafting of evergreens apply here.

Retinospora.

The finer varieties of this species are grafted by veneer grafting, yet a few varieties can be made from cuttings. R. ericoides, R. filefera, R. leptoclada, R. pisifera, R. pisifera aurea, R. pisifera lutescens. R. pisifera nana, R. plumosa, R. plumosa nana,

R. plumosa argenta, R. plumosa aurea, and R. aurea erecta: R. squarrosa sulfurea, R. squarrosa Veitchii and R. thuyoides, can all be made from cuttings.

Taxus.

The Tiger varieties are grafted on the English Yew, Taxus baccata. The method is the veneer graft and every rule in the grafting of evergreens applies here. Up to the present time I have found that they will not root from cuttings.

Thuya.

Whereas European growers propagate a large number of their Thuya by means of grafting in which the veneer graft is employed, we find that with the proper care, shading, watering, and bottom heat combined with good ventilation, all of the Thuyas can be made from cuttings. If the cuttings are taken in the fall, they can be taken out of the rooting bench in spring, but if a greater percentage is wanted, it is better to have them in the sand until the following September. They should then be put in beds properly shaded and covered gradually with leaves, after the first hard frost. Complete covering should usually take place about Thanksgiving.

— V —

Berberris.

The commoner types such as B. Thunbergii and B. Vulgaris are propagated by means of seeds. The finer varieties, B. Japonica and B. Ilicifolia, are made from cuttings. Cuttings are callused by putting them in moist media and keeping in a warm situation of from seventy to eighty degrees F.*

Chionanthus virginicus.

This plant known as White Fringe, is nevertheless grown from seed, but the seedlings of this plant is so unreliable that it is generally grafted. The stock in use in America by Veitch's Nurseries is Fraxinus excelsa; the root graft is the method in use and the time for it is in April. Veitch & Sykkis tell of making it as follows: "Root graft on Fraxinus Ornus in August under double glass. No heat required other than sun heat in the frame, not exceeding seventy degrees F. They are also propagated by layers in July - August in the fields. Plants grown from layers generally bloom better than grafted plants."

Leucodium Leucoliflorum.

All efforts to make these plants of hard wood cuttings have failed in my experience at Arlington Heights. They may be made by green cuttings under glass after July 20. They are also made by layerage in Europe. I have not tried layerage in America.

Euonymous.

The common forms of this genus are made by means of seeds, but the select varieties must be made either by means of grafting or green cuttings. The grafting must be done under double glass with

*B. Japonica is not Mahonia Japonica.

the heat about seventy-five degrees to eighty degrees F. The cuttings must be taken carefully so as to get some half-hardened wood at the cutting end. The usual treatment of the cutting bench is applied.

Spirea,

Most of the varieties can be easily made from hard-wood cuttings, but S. prunifolia flore pleno, and S. multiflora arguta do not give a good percentage as the other varieties. As a consequence we have been forced to make them from green cuttings in the summer time. Felix & Lykhuis say that they are also made of layers by the nurserymen of Holland.

Roses:-

This very fine assortment of plants is made generally by means of budding on seedling stocks. I have found that grafts are more certain during experiments at home. These are placed under double glass until well callused. They may be made from cuttings if care is taken in the selection of them, so that half ripened wood is obtained. European growers make them of hard-wood cuttings which are placed in the soil in March. The finer and harder varieties to propagate are then propagated on these rooted cuttings the following August by means of budding. Misses, otherwise known as those that do not take, are again propagated the following spring by grafting.

Actinidia Arguta.

The easiest method that we found for the propagation of these plants is by grafting a piece of the root on to a piece of the top while dormant and then putting them under double glass to callus.

Clematis.

These plants are made of green cuttings of half hardened wood. While in the cutting bench, C. Jackmanni do well, and if they

are put in pots they will also grow nicely; but if planted out of doors they seem to linger and finally die in a month or two. Nematods in the soil are the cause of this trouble, and we have found that much water having lots of soap suds, etc. is a very good remedy for the same, if constantly applied till well started.

— VI —

S E E D A G E.

Heretofore, I have mentioned that the common varieties of most plant genera are propagated by means of seed. The problems attached to seedage are as vital to the nurseryman as any of the other methods of propagation. Most of the agricultural seeds, such as corn, wheat, oats, rye, and barley, have soft coats which readily absorb moisture and germinate soon after conditions become favorable. Some of the horticultural seed also have this same character, but in the seed which the agriculturist uses, we find some varieties which do not have this character. Some of the clovers have hard coats, not easily penetrated by moisture, which consequently causes a delay in germination. On the other hand many of the horticultural seeds have such hard seed coats that they do not germinate the first year after they are planted. Some seeds, such as Rhus Aromatica, are said to remain in the soil as long as five years before they will all show a good germinating percentage.

Seed Treatment.

With these conditions in view I undertook a process of seed treatment for the purpose of forcing the earlier germination of seed as recommended by the New York Cornell Agricultural Station. This process as outlined by them in their bulletin #315, consisted of the treatment of seeds with sulphuric acid for variable lengths of time, in an effort to have the acid take off or soften enough of the seed coat so that moisture could get in and make the germination proceed at once. Concentrated sulphuric acid (Sp. Gr. 1.84) was used and the results as mentioned were very gratifying.

According to their bulletin, the seed was immersed in the

Seed Baskets, Plates, Blotters and Jars
Containing Sulphuric Acid.

acid for different lengths of time and then washed for about fifteen minutes in fresh water. Some of the results which they mentioned show an increase of from 55% in the untreated tests to 90% in the treated tests.

In an endeavor to obtain similar results, I treated a larger variety of seed with the acid. Samples of 100 seeds each were used and these were immersed in the acid for certain lengths of time by means of small copper wire baskets which were especially constructed for that purpose. (See illustration.) Then the baskets were put under faucets and cold running water was allowed to run over them. Agricultural seeds as well as horticultural seeds were used. The agricultural seeds were used because they did not require as long to germinate and would show a clearer and better result. These seeds were germinated by means of plates and moistened blotters, (See illustration,) while the horticlutural seeds were sown in a bench in the cool house of the vegetable greenhouses of the University. (See section illustrated.)

Tests with Agricultural Seeds.

The following tables indicate the time of treatment and the results of the germination of the agricultural seeds. In each case the test was run for at least fifteen days and all of the tests were examined daily.

1. Alfalfa.

Seed from Northrup, King & Co., Minneapolis, Minn.

Days	2	3	4	5	6	7	8	9	10	12	13	14	Total
Check	58	9	2	1	1			3		1			75
5 min.	41	27	3	1	2	1	1	1	1				78
15 min.	26	41	3		1	1		1				1	73
30 min.	55	15			1	2						2	75
45 min.	24	46	6	3							1	1	85

Variable result - No treatment can be recommended. Some of these seeds have been injured by the treatment.

Table 2. Burr - Clover.

Seed from J. M. Thornburn Co., New York City, N. Y.

Days	2	3	4	5	6	7	10	11	12	Total
Check		18	1	3	7	9				38
5 min.		1		30	3					34
15 min.	1	19	6	7	3			1		37
30 min.		17	9	5	1					32
45 min.		2	12	7	4	2	1		1	29

The use of H_2SO_4 seems to have injured the test and the results show that the acid treatment cannot be recommended.

Table 3. Lupine.

Seed from Northrup, King & Co., Minneapolis, Minn.

Days	3	4	5	6	7	8	10	11	12	13	14	Total
Check		4	30	17	2	1		1	1		1	47
5 min. acid.	3	7	9	2	14	3				1		39
15 min. acid.	5	10	13	3	1	1	2		1			36
30 min. acid.		3	36	5	2	1		1	1			49
45 min. acid.		2	35	7	2	1	1			1	1	50

Acid seemed to have but very little effect on these seeds. The results in this table do not seem to be of sufficient importance to recommend its use.

Table 4. Winter Wheat.

Seed from Northrup, King & Co., Minneapolis, Minn.

Days	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total.
Check	7	5	15	18	5	1	1	2	2	2		1			57
5 min. ac.		24	10	7	31		1		2	1	1				77
15 min. ac.	1	26	15	8	11	5					1			1	68
30 min. ac.	2	51		3	6		6	1			1			1	71
45 min. ac.			53	9	5	1					1		1		70

A slight increase may be attributed to the use of acid, and the most desirable effect from the use of the acid is the fact that a larger amount may germinate at one time.

Table 5. Alsike.

Seed from F. W. Thornburn Co.

Days	2	3	4	5	6	7	8	9	10	13	Total.
Check	82	1	1			1		1			86
5 min. acid.	4	69		1	1	2	1		1		79
15 min. acid.	63	14		2	1						81
30 min. acid.	63	18									84
45 min. acid.	66	14		1	3					1	86

This test shows that the use of acid in this case is not justified.

Plate and Blotter Germinators.

Table 6. Seed Sorghum.

Seed from T. A. Kaiser Seed Co., La Cygnet, Ariz.

Days	3	8	4	5	6	8	11	15	Total.
Check	69	6	3	1	1	1	1		76
5 min. acid.	42	33	5	3					71
15 min. acid.	69	21	1		1		1		73
30 min. acid.	51	18	3	1	3			1	75
45 min. acid.	41	36	2	1					80

Result: The use of acid is not justified in this instance.

Table 7. Durze.

Seed from U. S. Government.

Days	6	8	10	12	16	18	20	Total.
Check				3	1	5	4	13
5 min. acid.		1	2	2	9	2		16
15 min. acid.		1	1	4	4	3	1	14
30 min. acid.	2	1	1		8	3	3	18
45 min. acid		1	2	5	10		2	20

Result: A slight increase due to the use of acid. Not sufficient to be recommended on account of injury to the seed radicle.

Table 8. Yellow Trefoil.

Seeds from U. S. Government.

Days	1	2	3	4	5	6	10	Total.
Check	2	21	24	8		4	1	60
5 min. acid.	1	15	26	15		8		61
15 min. acid.	4	27	11	9	16		2	69
30 min. acid.	7	14	20	7		8		56
45 min. acid.	1	29	17	12		3	1	63

Result: A slight increase due to use of acid. Not sufficient to be recommended on account of injury to the seed radicle.

Table 9. Sweet Clover.

Seeds from U. S. Government.

Days	1	2	3	4	6	8	10	Total.
Check	6	25	10	17	5	2		65
5 min. acid.	2	34	8		4	3	3	55
15 min. acid.	11	41	7	1	3		1	64
30 min. acid.	14	38	9	2	4		1	68
45 min. acid.	7	41	6	8	3			65

Although this treatment was specially recommended for this seed, I find that treatment is unsatisfactory. When planted on one-tenth acre plots here at the University, the untreated plot was far superior to the treated plot.

Table 10. Scotch Broom.

Seed from U. S. Government.

Days	8	10	12	16	18	20	Total.
Check				2	1		3
5 min. acid.			3				3
15 min. acid.			1	2	2	1	6
30 min. acid.			5	5	1		11
45 min. acid.	4	5	4	6	2		21

In this case the use of acid seems to be a notable exception and it appears that the forty-five minute treatment can be recommended. A longer treatment might be beneficial.

Table 11. Genge Clover.

Seed from U. S. Government.

Days	2	3	4	6	8	10	12	16	20	Total.
Check	4	8	5	5	4	3				29
5 min. acid.	7	8	8	6	1			1		31
15 min. acid.	5	6	4	10	4	7				36
30 min. acid.	5	13	2	5	1	5	2			29
45 min. acid.	16	6	2	6	5	3			1	39

Acid seems to increase the germination about 10%, but the increase is not sufficient to make the treatment recommendable.

Table 12. Serradella.

Seed from U. S. Government.

Days	2	3	4	6	8	10	12	14	16	18	20	Total.
Check			1	33	18	14	5	3				74
5 min. acid.	3	9	7	22	12	6	6	5	1			69
15 min. acid.	7	22	2	35	8	7	2		2			85
30 min. acid.	7	7	1		12	5	4	2		1		40
45 min. acid.	10	23	12	6	2	2		1				56

No acid treatment can be recommended from the results given in this table.

Table 13. Bird's-foot.

Seed from U. S. Dept. of Agriculture.

Days	1	2	3	4	6	8	12	14	Total.
Check		37	47	21	2		1		98
5 min. acid.		61	26	1	1	1		1	91
15 min. acid.	56	28	8	4					96
30 min. acid.		84	9						93
45 min. acid.	55	26	10	1	1				93

Result shows that treated seed does not produce as great percentage as untreated. The notable result is that the treated seed germinates more uniformly.

Some three year old seed was also furnished to us by the Agronomy Department in order to see if the treatment would have any desirable effect. The following tables indicate the treatments:

Table 14. Grimm's Alfalfa.

Seed from University of Illinois.

Seeds three years old.

Days	1	2	3	4	6	8	10	12	15	Total.
Check		1	30	12	6	13	11	5		84
5 min. acid.	59	14	3	1	2	1				80
15 min. acid.	70	5	3	4	1	2	1			86
30 min. acid.	74	9	2		2					87
45 min. acid.	64	10	1		2				1	75

The only beneficial result from the use of acid in this case is the more even and quicker germination of the seed.

Table 15. Lupines.

Seed from University of Illinois.

Seeds three years old.

Days	4	5	6	7	9	11	13	15	Total.
Check	2	4	7	5	3	6	3	2	32
5 min. acid.	14	7	7	6	4	7	4		49
15 min. acid.	28	4		1	1	1	1		36
30 min. acid.	31	6	1				4	1	43
45 min. acid.	17	8	7	1				1	34

Result is very irregular, due to the irregularity of the sizes and qualities of seeds. Large seeds of this variety always germinate better than small seeds.

Table 16. Vetch.

Seed from University of Illinois.

Seed three years old.

Days	3	4	5	6	7	8	10	11	12	13	14	15	Total.
Check	1	2		11		6	2		1		1	2	26
5 min. acid.		7		9		13	1						30
15 min. acid.	6	6		10		6	2		1	3			34
30 min. acid.	3	8				5	1		3				20
45 min. acid.		30	2		1			1				1	35

Although the treatment shows a slight variation, I believe that this is due in part to the variation in the quality of the seed. Therefore, I cannot recommend the use of acid.

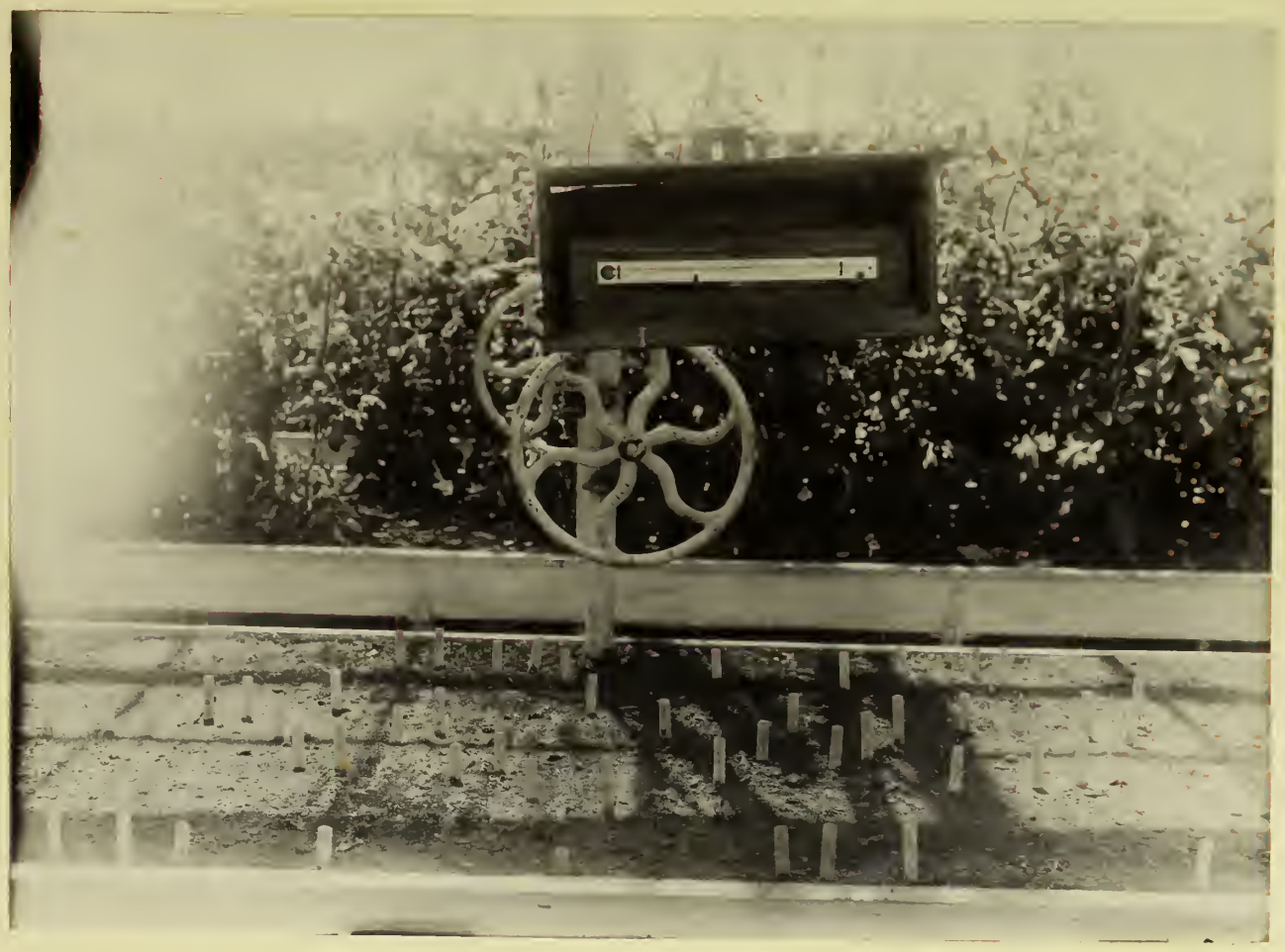
Table 17. Alsike.

Seed from University of Illinois.

Seed three years old.

Days	1	2	3	4	5	6	8	9	10	11	12	14	15	Total.
Check		15	15	10		10	3		4		2	1		60
5 min. acid.	7	24	12	8		9	3							73
15 min. acid.	20	27	10			4	3							64
30 min. acid.		13	25	14	7			4		6				69
45 min. acid.	23	22	16	4		2	3		1				1	72

A very slight increase probably due to acid. Note the difference in time of germination of the treated and untreated seeds.



Section of Horticultural Beds in Bench

Hot Water Test.

A number of samples of seeds were treated with warm water as recommended for a number of hard coated seeds. The seeds were allowed to remain in the water twenty-four hours. When the seeds were put in the water registered eighty-six degrees C., and when the seeds were taken out the temperature was twenty-two degrees C. - The following table indicates the results:

Table 16.

Variety of Seeds	1	2	3	5	7	9	13	15	Total.
Vetch					1	2		2	5
Lupine, 3 yr. old	26	30	4	2	2				64
Vetch, 3 yr. old			1	6			1		8
Grimm's Alfalfa, 3 yr.	.....								No result.
Bur Clover	.....								No result.
Alsike, 3 yr. old		3						1	4
Mammoth Clover	.....								No result.
Yellow Trefoil			1						1
Scotch Broom							4		4
Genge Clover			1	8	2		1		12
Sweet Clover	.....								No result.
Sanfoin	.....								No result
Sand Lucerne	.....								No result.
Serradella	.....								No result.

Summary of the Results from the Treatment of the Agricultural Seeds.

1. Nine varieties of the thirteen tested do not seem to show any beneficial results from the acid treatment.

2. The only one showing any marked increase in germination is Scotch Broom, the increase being from 3% in the check (untreated) to 21% in the sample having a treatment of forty-five minutes. Winter Vetch, Genge Clover, and Alsike showed some favorable result, but

treatment is unrecommendable because of irregular germination.

3. Injury from the acid was apparent in a number of cases, the injury showing when the seed radicle was exposed. Those hurt by the treatment would have a brown rotting tip which would be devoid of root hairs. The growth of the radicle would soon stop and entire decaying would then begin.

4. The treatment with hot water showed that only one variety could endure that treatment with benefit. This variety was the Lupine known as Lupine.

5. In the Lupines as well as other seeds, I found that the large seeds were the ones to germinate first, the others germinating later or not at all.

Since these experiments were completed, I have received Press Bulletin No. 56 from the Iowa Agricultural Experiment Station. This bulletin of April, 1917, is the "Announcement of the Perfecting of a Method for Increasing the Germination of Legume Seed." In this bulletin we find "that the farm crops section of the Iowa Agricultural Experiment Station has built a practical machine by the use of which it is possible to increase to over 90% the germination of legume seed, which before treatment did not germinate more than 5%."

Tests With Horticultural Seeds.

As I have previously mentioned, these seeds were planted in the greenhouse after treatment. The size of the plot was limited with the exception of Dwarf Mericans, of which there were fifty, all samples contained one hundred seeds. Ten varieties were planted November 23, 1914; five more were planted December 15, 1914, and the

remaining five were planted January 15, 1915. These were kept moist in a good germinating condition and the young seedlings were pulled out and counted about every fifteen days. Due to the fact that I was forced to go home on account of typhoid fever, no counts were taken between March 3 and April 20, 1915. The following tables indicate the variety of seed planted, the time of planting, the time of counting, and the length of acid treatment, with results:

Table 19. Rosa Arkansana.

Pulled out and counted.

Planted 11/23/14	1/20/15	1/31	2/15	3/3	4/20	5/1	5/15	Total.
Check No. treat.				3	1			4
15 min. treat.	3		1			1		5
30 min. treat.	2				1			3

These seeds have very hard coats and germinate very irregularly. This treatment with sulfuric acid does not seem to be of any benefit. Scarifying or filing of the seeds would probably bring better results.

Table 20. Eleagnus Angustifolia.

Pulled out and counted.

Planted 11/23/14	1/20/15	1/31	2/15	3/3	4/20	5/1	5/15	Total.
Check No. treat.		2	4	12	25	14	11	68
15 min. treat.	4	1	2	9	28	22	10	76
30 min. treat.	1	1	1	5	34	30	10	82

These were seeds with the hulls unremoved. The acid treat-

ment seems to be of some benefit to this variety inasmuch as an increase of fourteen is shown over the check sample. However, these seeds seem to germinate easily if they are kept in a moist situation. The commercial use of sulphuric acid on this variety of seeds might be of some benefit to the nurseryman.

Table 31. Berberis Thunbergii.

Hulled out and counted.

Planted 11/23/14	1/20/15	1/31	2/15	3/3	4/20	5/1	5/15	Total.
Check No. treat.			1	6	13	4	2	26
30 min. treat.		3		2	9	4		18

These seeds were also unhulled. The treatment of acid does not seem to benefit the sample any. If the seed coat was well macerated and cut off, it need not be treated with anything and it will show a very satisfactory germination. The acid does not seem to be very effectual against the seed coat of the Barberry.

Table 32. Xanthoxyllum Americana.

Hulled out and counted.

Planted 1/23/14	1/20/15	1/31	2/15	3/3	4/20	5/1	5/15	Total.
Check No. treat.				3	3			6
15 min. treat.				2		1		3
30 min. treat.			2	1	4			7
45 min. treat.			1	2	3	1		7

The result does not indicate that any benefit can be gained by using sulfuric acid for treatment.

Table 23. Viburnum Carlesiaeum.

Pulled out and counted.

Planted 11/25/14	1/20/15	1/31	2/15	3/5	4/20	5/1	5/15	Total.
Check No. treatment.				3	9	3	9	24
15 min. treatment.					9	2	4	15
30 min. treatment.					6	1	2	9
45 min. treatment.							2	2

Result indicates that sulphuric acid is probably injurious in this treatment.

Table 24. Cornus Siberica Alba.

Pulled out and counted.

Planted 11/ 3/14	1/20/15	1/31	2/15	3/5	4/20	5/1	5/15	Total.
Check No. treatment.					2	13	39	54
15 min. treatment.						15	30	45
30 min. treatment.					1	43	26	70
45 min. treatment.					1	4	30	35

The seed in this sample seems to be irregular and the sulphuric acid does not seem to benefit the germination of this variety

Table 25. Prunus Serotina.

Pulled out and counted.

Planted 11/25/14	1/20/15	1/31	2/15	3/5	4/20	5/1	5/15	Total.
Check No. treatment.						1	1	2
15 min. treatment.								0

Due to the fact that I only possessed a few seeds of this variety, I only treated one sample. This treatment seemed to indicate that it is a waste of time and labor. It should have probably been frozen before planting.

Table 26. Viburnum Fuscum.

Pulled out and counted.

Planted 12/15/14	1/20/15	1/31	2/15	3/2	4/20	5/1	5/15	Total.
Check No. treatment.			2	27	11	14		54
15 min. treatment.			4	33	10	8		55
30 min. treatment.			3	30	9	6		48
45 min. treatment.			10	31	4	4		47

The total shows that no beneficial result may be expected from the use of sulphuric acid.

Table 27. Thuya Occidentalis.

Pulled out and counted.

Planted 1/15/15	1/20/15	1/31	2/15	3/2	4/20	5/1	5/15	Total.
Check No. treatment.					14			14
15 min. treatment.								0
30 min. treatment.								0
45 min. treatment.								0

The acid injures this type of seed completely so that it will not sprout.

Table 29. Pinus Austriaca.

Pulled out and counted.

Planted 1/15/15	1/30/15	1/31	2/15	3/3	4/30	5/1	5/15	Total.
Check No. treatment.			9	6				15
15 min. treatment.				8				8
30 min. treatment.				6				6
45 min. treatment.				4				4

No beneficial result can be expected from the use of acid.

Table 29. Pinus Strobus.

Pulled out and counted.

Planted 1/15/15	1/30/15	1/31	2/15	3/3	4/30	5/1	5/15	Total.
Check No. treatment.					20	19	1	40
15 min. treatment.					21	10	2	33
30 min. treatment.				1	34	8	5	48
45 min. treatment.				6	21	3	4	34

These variable totals indicate that no beneficial result may be expected.

Table 30. Prunus Pennsylvanica.

Pulled out and counted.

Planted 12/15/14	1/30/15	1/31	2/15	3/3	4/30	5/1	5/15	Total.
Check No. treatment.								0
15 min. treatment.							1	1
30 min. treatment.								0
45 min. treatment.								0

No beneficial result obtained from the use of sulphuric acid.

Table 31. Viburnum Lentago.

Pulled out and counted.

Planted 12/15/14	1/20/15	1/31	2/15	3/3	4/20	5/1	5/15	Total.
Check No. treatment.						1		1
15 min. treatment.								0
30 min. treatment.								0
45 min. treatment.								0

No beneficial result can be reported for the use of sulphuric acid.

Results from the Treatment of the Horticultural Seeds.

1. Of the twenty varieties of seeds planted, only thirteen showed any results of any kind.

2. Those not germinating are:-

a. Sorbus Americana (planted 11/23/14)

b. Prunus Americana (planted 11/23/14)

c. Ilex Verticellata (planted 11/23/14)

d. Rhodotypus Kerroides (planted 12/15/14)

e. Aronia Melanocarpa (planted 12/15/14)

f. Abies Canadensis (planted 1/15/15)

g. Tilia Americana (planted 1/15/15)

3. Only one variety (Elaeagnus Angustifolia) showed an increased germination from the use of sulphuric acid. The increase was only 14%. Quercus Alberis Alba, and Pinus Strobus showed favorable tests but treatment cannot be recommended due to the irregularity of germination.

Conclusions.

Since no notable success can be achieved, the use of sulphuric acid as a germination accelerator should be discarded. This result is unanswerable I have shown by the treatment of both agricultural and horticultural seed. Filing of some hard seeds might be a feasible method, and if some good commercial filing or scarifying method can be found, undoubtedly some satisfactory results might be obtained. Horticultural seeds still offer a wide field for further experiment.

A FEW SUGGESTIONS FOR TESTING TREE SEEDS GROWN.

The first step should be to purchase the seed from a reliable source. Cheap seed should be avoided, because the usual result from cheap seed germination indicates an ultimate loss of money and time which is larger than the original saving. Reliable seed is seed which is fresh, of average germination quality, and true to name. Some kinds will unavoidably show a large percentage of empty hulls, but most varieties of plants should show at least 75% of sound kernels. The most dependable test is germination, but since it takes a long time for some seeds to germinate, a simple yet unreliable test is to cut open the seeds and note whether the kernels are in a fresh and sound condition.

Probably the best method for making a test of tree and shrub seeds is to put a fine sandy loam in a shallow box, pan or bench. In order to provide good drainage, gravel, broken bricks, or other porous material should be first put in the bottom of the box. After the soil has been thoroughly tamped until it is compact, it should be watered before the seeds are sown. Then select 100

seeds of each variety and sow them, either broad-cast or in rows. These should be covered with sand or better still with sand and moss a trifle deeper than one would ordinarily cover agricultural seeds. The seed bed should be kept moist and must be in the sunlight with an average temperature of at least seventy to eighty degrees F. Records may be kept daily; each germinating seed will be 1/100 of the total or represent one per cent. Fair percentages may be expected but one should not be discouraged if they do not always receive a germination of ninety per cent during the testing period.

Vitality of Seeds.

Some kinds of seeds, especially maples, elms, birches, willows, etc. do not retain their vitality very long and should be sown immediately after ripening. These are generally the soft shelled kinds. A number of seeds show a decreased germination the second year if they are held over that long. Locust, gymnocladus, red bud, and other very hard shelled seeds are found to be serviceable for several years. Soft shelled pine seeds deteriorate rapidly after the first year, while the very hard shelled varieties such as Pinus ponderosa, sabine, etc. have been known to give fair results though they were several years old.

Where to Sow.

Large quantities are best sown in properly prepared seed beds. In order to eradicate the weeds to a great extent and to give the beds proper initial preparation, it is advisable to manure the field heavily the first fall, then plow under to a depth of at least twelve inches. Sub-soiling may be practiced and is generally found more beneficial than very deep plowing. It loosens up the soil, allowing greater aeration and drainage. Then keep the soil in the

best possible state of tilth for one whole year, sowing nothing in the land but keeping up a constant cultivation and harrowing. This cultivation should be kept up as late as possible, even until the ground becomes frozen. During this cultivation all sticks and stones should be removed and the soil should be brought up to its highest state of tilth. Where the soil is naturally too heavy, add some sand and where it is too sandy, add some heavy loam. If the field is manured during the year that it is worked repeatedly, only composted or well rotted manure should be used. Fresh manure is sure to contain weed seed which will germinate the following year. Beds five feet wide are most convenient to handle, but they may be unlimited in length.

For small quantities and rare seeds I wish to recommend shallow boxes from three to four inches deep. If many boxes are to be used, it is often advisable to have all of the boxes uniform in size. If good drainage is not provided by the cracks in the box, holes should be bored in the bottom for that purpose. Then fill the box about three-fourths full of a fine sifted sandy loam. Compact this after leveling. Then sow the seed, cover with a little of the sandy loam or sand and mulch with a layer of sphagnum moss or similar material. Seeds may be sown in boxes in the fall, brought into a dry basement and taken out in the spring.

How to Sow.

Seeds may be sown broadcast, but when one wishes to keep the boxes free from weeds and obtain sturdier plants, he should prefer sowing in rows. The depth of sowing should depend on the size and the variety of the seeds. Seeds should not be covered very deeply; usually rather sparingly and generally not more than twice

the diameter of the seed. Some seeds, such as the conifers, should be given only a very thin covering, while Gleditschias for instance, will germinate better if covered to a depth of about two inches.

For quick growing plants the distance between rows should be about nine to twelve inches. For slow growers and careful hand cultivation, they may be four or five inches apart, while for horse cultivation rows should not be less than three and one half feet apart, nor should the rows be laid in beds. The seeds should not be planted too thickly, and after sowing it is often well to firm them. A thin mulch of well rotted manure or similar material will keep the soil in even moisture and protect the seeds from the direct rays of the sun. The mulch should be gradually removed as the seedlings appear. Both screens or lath houses are preferred in many cases by growers, especially those growing conifers.

Seed Treatment Before Sowing.

Treatment of seeds by dipping in hot water is often recommended for hard shelled seeds. Water about one hundred and twenty degrees F. is used; yet some seeds will lie in the ground for one, two or even three years without germination. Those seeds having thick pulps should have their pulps macerated (removed in water) before sowing. After that is done they should be immediately planted or stratified. By stratification we can keep seeds for the winter. This is accomplished by means of putting the seeds between layers of sand in boxes and keeping them where the mice cannot get them. In order to protect the seeds from the birds, they may be dipped in lead paint before sowing.

Care of Beds.

Very little water should be found necessary if the beds are properly mulched, but if necessary, water early in the morning or late in the afternoon. Be careful of "Damping Off," and use only a fine spray. "Damping Off" is often prevented by thin sowing, frequent cultivation, and it is sometimes cured by sprinkling powdered charcoal, dry sand, or dusting flowers of sulphur over the bed which is infected.

After the seedlings appear, they should be watched closely. Light, careful cultivation should be practiced; shading should be carefully attended to, and the necessary watering should be judiciously administered. Conifers should be pricked off very early after germination and they should be transplanted repeatedly. Other plants may remain in the beds until the following transplanting season, when they may be put in nursery rows.

Sowing Under Glass.

Very small seeds, such as those of Andromeda, Azalia, and Rhododendron, may preferably be sown under glass. The use of seed pans with a finely sifted peat loam is advised. The pans should have thorough drainage, but should never become dry. They should be watered with a very fine rose can. Cover the pans with a pane of glass so as to give the seeds a greater heat and greater humidity. Transplant and prick off seedlings as soon as one leaf is plainly discernible. Transplant often in order that the plants may be put out into the open ground in the spring of their second season.

Herbaceous Plants.

Boxes will be found more desirable than beds except when exceedingly large amounts are required. Fall sowings are preferred.

They should generally produce flowering plants for the next season. Seeds having hard shells should be soaked hot even these some times lay over for a whole year.

Ferns.

Fern spores are best sown under glass in well drained pans filled with coarse peat or on pieces of peat in pans of water. The spores should be sown evenly and thinly and brushed down. They must be watched closely for "Damping Off." Keep them in an even shade and give a temperature of not less than seventy degrees in the night time. Prick off the seedlings as they appear but be careful in transplanting so as to keep the crowns above the soil.

A LIST SHOWING THE BEST TIME AND METHOD OF SOWING.

A. Seeds of short vitality to be sown promptly after ripening.

B. Seeds best sown in full.

C. Seeds to be sown in Fall or to be stratified.

D. Seeds to be sown in early Spring.

E. Seeds to be sown after ground is well warmed in Spring.

F. Seeds which should be stratified but which may "lay over" a year or longer before germinating.

G. Seeds to be soaked in very hot water immediately before sowing.

H. Seeds with thick pulp which should be washed off just before sowing or which should be stratified after being washed.

I. Seeds of hardy plants best sown under glass.

J. Seeds of tender plants to be sown under glass.

Abies	I	Alnus	C	Aralia	H
Acacia	J	Althaea	E	Arbutus	I I
Acer (1)	A	Amelanchier	F	Arctostaphylos	C
Aesculus	C	Amorpha	E	Ardisia	J
Ailantus	B	Ampelopsis	H H	Aristolochia	H
Albizzia	I J	Andromeda	I I	Asimina	H G

Azalea	I	Ginkgo (1)	1	B	Persea	2	F
Berberis	D	H	Gleditsia	3		Picea	2	
Betula	A		Gordonia	2		Pieris	2	I
Buxus	D	G	Gymnocladus	D	3	Pinus	2	
Callicarpa	D		Halesia	2	F	Platanus	2	
Calycanthus	E		Hamamelis	2	F	Populus	A	
Camphora	B		Hedera	2		Prunus	3	F
Caragana	E	G	Heteromeles	2	F	Pseudotsuga	2	
Carpinus	A		Hibiscus, hardy	2		Ptelea	B	2
Carya	D		Hibiscus, tender	J		Pyrus	2	F
Castanea	C		Hicoria	2		Quercus (2)	2	
Castanopsis	C		Hydrangea	2	I	Rhamnus	2	
Catalpa	D		Ilex	G	F	Rhododendron	2	I
Ceanothus	E		Itea	E		Rhus	2	
Celastrus	E		Juglans	2		Robinia	2	3
Celtis	E		Juniperus	2		Romneya	2	
Cephalanthus	E		Kalmia	I	E	Rosa	B	3	E
Cercis	E	G	Koelreuteria	2		Rubus	C	3	F
Chamaecyparis	E		Laburnum	3	E	Sambucus	2		
Chionanthus	D		Lagerstroemia	2		Sassafras	2		
Citrus	C		Laurus	3	-	Schinus	2		
Clematis	D		Larix	2		Sequoia	C		
Clethra	E		Leucothoe	I	E	Smilax	D		
Cliftonia	I	E	Libocedrus	2		Sophora	2		
Colutea	C	E	Ligustrum	3	E	Sorbus	2	3	
Cornus	D		Lindera	3	E	Spartium	C	3	
Corylus	C		Liquidambar	2		Spiraea	2		
Crataegus	F	E	Liriodendron	3	E	Staphlaea	D		
Cupressus	E		Lonicera	2		Stuartia	2		
Cytisus	C	E	Maclura	2		Symphoricarpus	C		
Diospyros	D		Magnolia	3	E	Syringa	2		
Dirca	E		Melia	2		Tamodium	2	E	
Dracaena	E	I	Menispermum	2		Tecoma	2		
Elaeagnus	E		Mohrodendron	3	E	Thuya	C		
Eucalyptus	3	E	Morus	2		Tilia	C		
Euonymus	E		Myrica	2		Torreya	2		
Exochorda	D		Nerium	3		Tsuga	2		
Fagus	2		Nyssa	2		Ulmus	A		
Fothergilla	B	G	Opuntia	2	I	Umbellularia	2	F	
Fraxinus	B		Ostrya	2		Viburnum	E	3	
Fremontia	E		Oxydendron	2	I	Vitis	2		
Gaultheria	C		Paulownia	2		Wisteria	2		
						Yucca	2		

1. Acer Negundo and Acer rubrum are more perishable than most other species.

2. Gingko seed usually are sold washed.

3. Some species - those belonging to the White Oak family especially - must be sown immediately after ripening. They do not keep.*

*The list shown above is prepared for the nursery trade by Otto Katzenstein & Co., Tree Seedsmen, Atlanta, Georgia., U. S. A.

In regard to seed germination, the following various notes have been received:

"Wild rose seeds should be gathered before the hips get soft and color, then they should be macerated at once, then cleaned in water, and the blanks run off. This will leave less than half of the seeds taken out of the hips." (From Ehlers Nurseries)

"Seeds such as Craetagus, American Linden and Norway Rosea varieties require careful stratification before they are ready to germinate. Most Evergreen seeds germinate without being stratified, but you will find Abies Canadensis, the native Hemlock, rather hard to germinate, as is also Pinus Strobus, as the germination is uneven. Pinus Austrica germinates very readily but is subject to 'Damping Off' as soon as the young plants are out of the ground. Betula Alba and Betula Lutia require very careful handling to grow the seedlings." (From The D. Hill Nursery Company, Inc.)

"JUNIPERUS - The seeds of the common sort J. communis are stratified as soon as they are gathered, left a whole year in the sand and sown the following spring. Some nurserymen gather the seeds of this sort just before they are fully ripe, that is when they are still green, the seeds are at once cleaned and stratified. Thus treated most of the seeds germinate the following spring. This has the benefit of gaining one year but it must be done at the right time. J. Virginiana germinate the first year. As soon as gathered the seeds are cleaned, stratified at once and sown the following spring.

"CRATAEGUS - All the sorts we grow have to be stratified a whole year. The berries are cleaned and stratified not later than February.

"TAKING - If gathered when green, must be just before they are fully ripe and stratified at once, the seeds germinate the first year. If gathered ripe the seeds are placed in a well aerated room for drying, put in sand or cake, stratified in July - August and sown in the following spring."(From Graines & Tiges, Orleans, France)

VII

SUMMARY OF INFORMATION.

1. Cheaper, quicker, easier methods of propagation which give a greater number of plants from a given amount of stock are needed by American nurserymen in order to counterbalance the climatic and economic advantages enjoyed by European propagators.

2. The selection of stocks for fruits is of vital importance to the fruit grower. For longevity to the apple, Northern type stock should be used. Pear will probably receive more demand if worked on Quince. Cherries do better in some parts of the country on American Morello root stock. Plums will endure the winter freezes if grafted on hardy American stock. The possibility of growing all varieties of grapes here seems feasible if the proper stocks are used.

3. European propagators are more proficient in growing ornamental stock. American propagators must search for methods which will enable them to overcome difficulties due to unfavorable climatic conditions. The possibilities of production in this department seem to be unlimited, as the expansion of American planting is creating a great demand.

4. The use of Sulphuric acid as a charrer of seed coats to assist in germination is not productive of desirable results. Mechanical treatments by the use of a scarifyer is sure to present many advantages over the chemical treatment of seeds.

5. Continual experimentation with careful attention to all details is necessary before success can be attained in the growing of horticultural seedlings.

F I N I S.